LQ search in eejj channel

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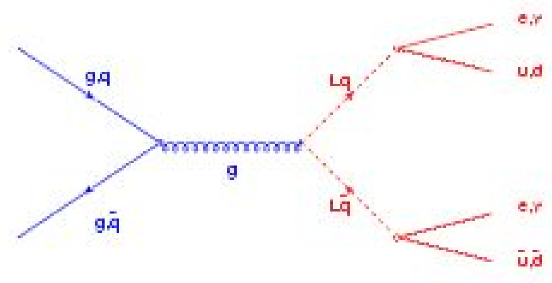
preblessing

Introduction

- This analysis is an update of the result produced in March 2003
- REMAKE data 4.11.1 up to Summer shutdown used - 203 pb^{-1}
- New categories added
  - use now CC and CP electrons;
- New good run list
- New evaluation of efficiencies and background
  - fakes

LQ production at the TeVatron

- Production
  - qg → LQ + LQbar
  - gg → LQ + LQbar
  - qqbar → LQ + LQbar



- Decay
  - LQLQ → l^+l^-qq, $l^\pm\nu$qq, $\nu\nu$qq

β = Br(LQ->eq)

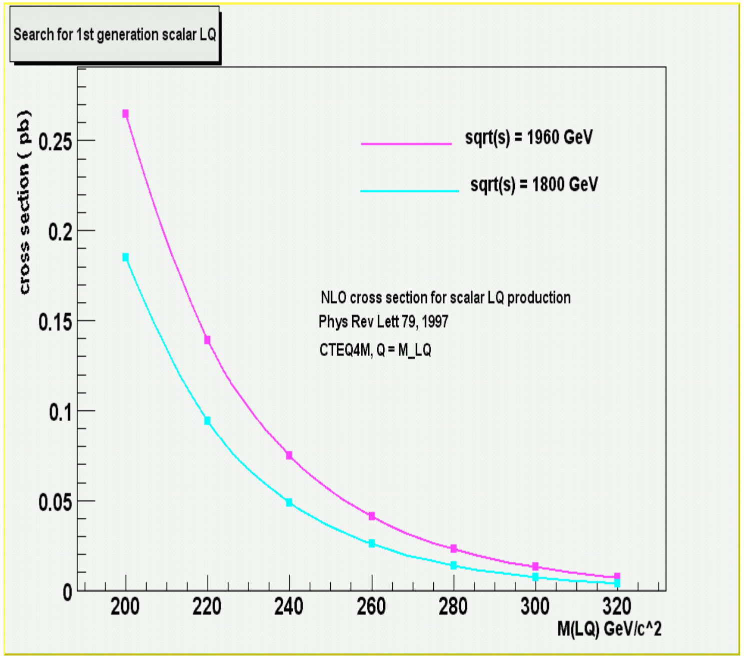
- Experimental signature:
  - High pt isolated leptons (and/or MET) + jets

LQ production at TeVatron

Code from Michael Kraemer (Phys.Rev.Lett 79,1997)

s = 1960 GeV
$Q^2 = M_{LQ}^2$
CTEQ4M pdf

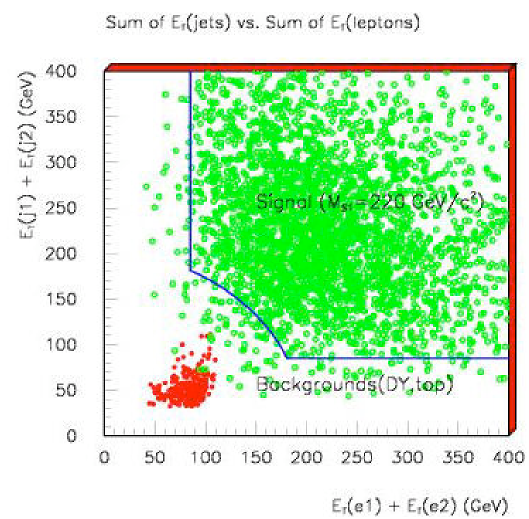
M_{LQ} (GeV/c^2)	□(NLO) [pb]
200	0.265E+00
220	0.139E+00
240	0.749E-01
260	0.412E-01
280	0.229E-01
300	0.129E-01
320	0.727E-02



LQ search in eejj

- 2 ele with $E_T > 25$ GeV
- 2 jets with $E_T(j1) > 30$ and $E_T(j1) > 15$ GeV
- removal of events with $76 < M_{ee} < 110$ GeV and $M_{ee} > 15$ GeV
- $E_T(j1) + E_T(j2) > 85$ GeV && $E_T(e1) + E_T(e2) > 85$ GeV
- $((E_T(j1) + E_T(j2))^2 + (E_T(e1) + E_T(e2))^2) > 200$ GeV

High P_T electron triggers (ele_18 and Ele_70)
One tight electron and one loose or plug



Tools

- Signal generated and reprocessed with 4.9.1
  – 5000 events at masses from 200 to 320
    - run number 151435
    - full beam position
      – talk GenPrimVert
      – BeamlineFromDB set false
      – sigma_x set 0.0025
      – sigma_y set 0.0025
      – sigma_z set 28.0
      – pv_central_x set -0.064
      – pv_central_y set 0.310
      – pv_central_z set 2.5
      – pv_slope_dxdz set -0.00021
      – pv_slope_dydz set 0.00031
      – exit
- eN (4.9.1 + patches) used for ntuple analysis
  – http://ncdf70.fnal.gov:8001/talks/eN/eN.html

Tools (cont'd)

- Background MC - 4.9.1
  - DY + 2 jets
    - generated with alpgen + HERWIG
      - For cross section we used mcfm NLO
      - 50K events for $15 < m_{ee} < 75$
      - 27.5K events for $75 < m_{ee} < 105$
      - 50K events for $105 < m_{ee} < 800$
  - Top
    - Pythia 5K events tt into dileptons

- Fakes from data, with isolation method and same-sign method as cross check;

Efficiencies & acceptance

$$\boxed{\epsilon_{tot} = \epsilon_{Acc}(M) \times \epsilon_{ID} \times \epsilon_{z0} \times \epsilon_{trig}}$$

- Trigger
  - Top/EW - same as in Z` analysis
    - 99.9 CC
    - 96.8 CP
- Efficiencies for electron selection cuts
  - From Z' analysis
    - $\epsilon_{CC} = 92.4 \pm 0.4$
    - $\epsilon_{CP} = 79.2 \pm 0.4$
- Others
  - efficiency on the vertex cut: 95.1 ± 0.1 (stat) ± 0.5 (sys)

Kinematical and geometrical acceptance

- Events are selected where the HEPG electron is matched in a □R = (□□^{2} - □□^{2}) cone to the reconstructed electron ;
  - Events are further selected if falling in one of 3 categories (geometrical acceptance - □^{fid}):
    - events with 2 central electrons (fidele == 1)
    - events with 2 central-plug electrons (1 < l□ l < 3)
    - events with 2 plug-plug electrons (1 < l□ l < 3) -- tiny
  - Weights are derived for the 3 contributions ;
- The kinematical cuts are applied and the resulting efficiency weighted according to the CC or CP population.

Electron ID (Z' analysis)

- Central electron (loose or tight)
  - $E_t \geq 25$ GeV
  - $p_t > 15$ GeV
  - hadem <= 0.055 + 0.00045 * E
  - E/p < 4 (for $E_T > 100$ GeV)
  - iso4e/emet < 0.1 (0.2 for second central loose)
  - lDeltaX l < 3.0
  - l DeltaZ l < 5.0 cm
  - Fiducial = 1
  - lshr < 0.2

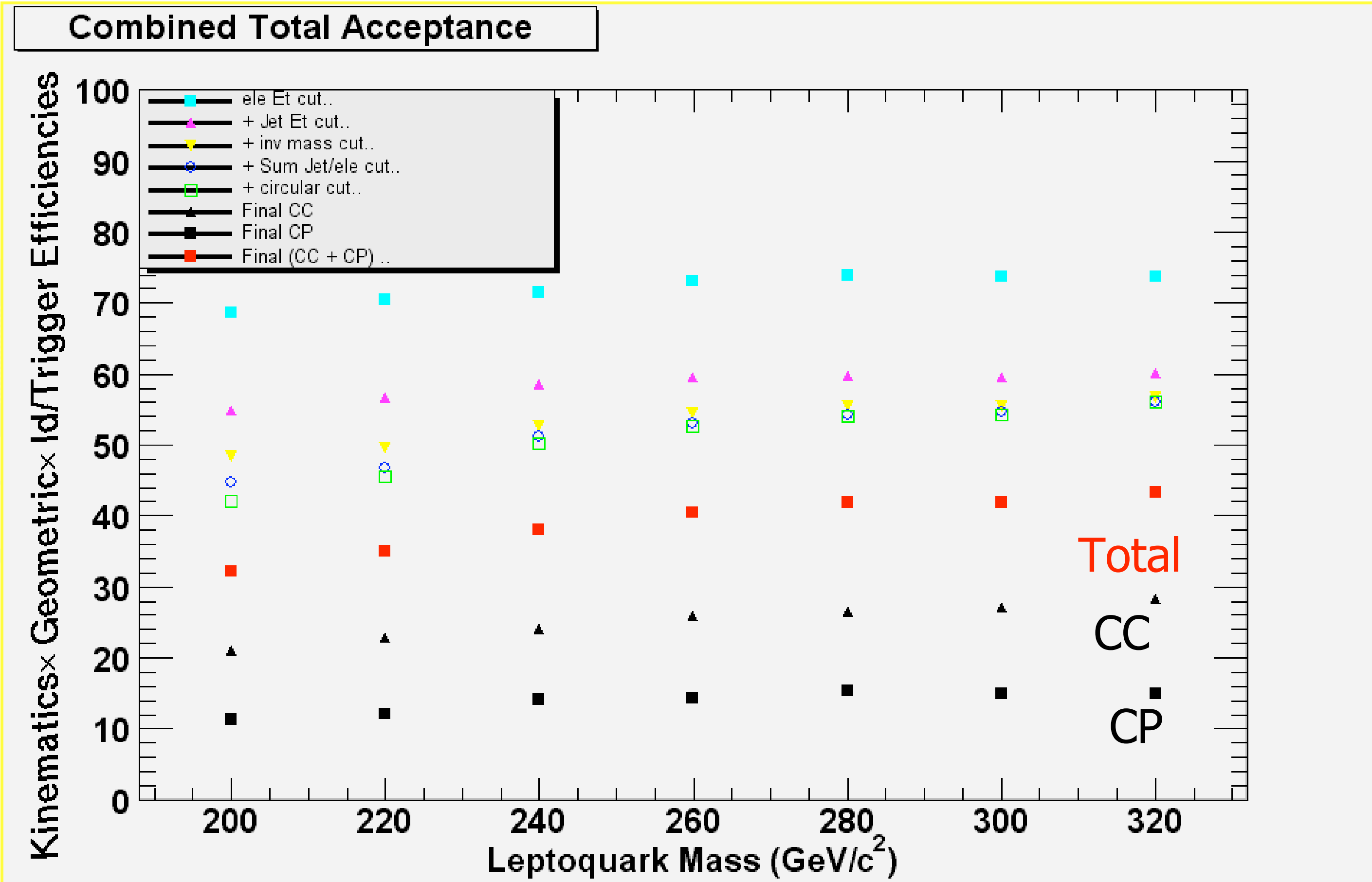
$\varepsilon_{CC} = 92.4 \pm 0.4\%$

$\varepsilon_{CP} = 79.2 \pm 0.4\%$

Second Loose Plug electron

- $E_t \geq 25$ GeV
- Isolation < 0.1
- hadem <= 0.055 + 0.00045 * E
- $\chi^2_{3x3} < 10$
- Fiducial $1 < |\eta| < 3$

Total acceptance



Background expectations

tt with both W ->e	pythia	0.35 ±0.03 events
DY + 2 jets	alpgen+PS/mcfm	1.89 ±0.44 events
Fakes	Isolation	4.0 ± 2.0 CP
		$0.0^{+0.7}_{-0}$ CC
	Total	$6.24^{+3.1}_{-2.5}$

Isolation method

- The isolation method relies on the assumption that since jets are produced in association with other particles, the isolation fraction of a jet will be generally larger than the corresponding one of an electron. The phase space corresponding to the 2 electrons isolation fractions is divided in 4 regions:
- For central-central :
  - Region A) $Iso_1^{central} < 0.1$, $Iso_2^{central} < 0.2$;
  - Region B) $Iso_1^{central} < 0.1$, $0.2 < Iso_2^{central} < 0.4$;
  - Region C) $0.2 < Iso_1^{central} < 0.4$, $Iso_2^{central} < 0.2$;
  - Region D) $0.2 < Iso_1^{central} < 0.4$, $0.2 < Iso_2^{central} < 0.4$;
- For central-plug:
  - Region A) $Iso_1^{central} < 0.1$, $Iso_2^{plug} < 0.1$;
  - Region B) $Iso_1^{central} < 0.1$, $0.2 < Iso_2^{plug} < 0.4$;
  - Region C) $0.2 < Iso_1^{central} < 0.4$, $Iso_2^{plug} < 0.1$;
  - Region D) $0.2 < Iso_1^{central} < 0.4$, $0.2 < Iso_2^{plug} < 0.4$;

Isolation method (cont'd)

- We used 2 samples:
  - lepton P_T cut at 25 GeV
  - relaxed cut at $P_T > 20$ GeV (to let in more events)
- Extrapolating the contributions from the lower P_T cut region we estimate in the $P_T > 25$ sample
  - 0 events in the CC region (also 0 s.s. events)
  - 4 ± 2 events of background in the CP region
    - A 2
    - B 0.66
    - C 0.66
    - D 0.106
    - Although we don't make use of tracking info for plug electron - even if using DefTrack - we still find one same sign event (□^{ele} = 1.1)

Data sample

- btop0g (inclusive electrons) stripped from bhel08 and (4.8.4 Production)
- Inclusive-ele_4.11.1_REMAKE
- events selected from Ele_18 && Ele_70 triggers
- good runs from March 2002 to September 2003 (141544 - 168889)
  - Good run list from DQM page, em_noSi version 4
    - Removed 4 runs due to CSL problem
    - Luminosity = 199.7 * 1.019 = 203.5 ±12.2
    - http://www-cdf.fnal.gov/internal/dqm/goodrun/v4/goodv4.html

Data sample

```
module clone   Prereq HPTE
module enable  Prereq-HPTE
module talk    Prereq-HPTE
  L1Accept       set true
  L2Accept       set true
  L3Accept       set false
  L3TriggerNames set ELECTRON70_L2_JET          \
                     ELECTRON_CENTRAL_18        \
                     ELECTRON_CENTRAL_18_NO_L2 \
                     W_NOTRACK                  \
                     W_NOTRACK_NO_L2            \
                     Z_NOTRACK
  debug         set false
exit
exit
```

```
module clone   StripSingleE HPE2
module enable  StripSingleE-HPE2
module talk    StripSingleE-HPE2
  elePtMin set 15.0
  etCalMin set 70.0
  delXMin  set  3.0
  delZMin  set  5.0
  show
exit
```

```
module clone   StripSingleE HPE1
module enable  StripSingleE-HPE1
module talk    StripSingleE-HPE1
  elePtMin set  9.0
  etCalMin set 18.0
  delXMin  set  3.0
  delZMin  set  5.0
  EoPMax   set  4.0
  lshrMax  set  0.3
  hademMax set  0.125
  show
```

Z cross section check

- Z boson candidates selected by requiring:

$$70 \text{ GeV} < M_{ee} < 110 \text{ GeV}/c^2$$

- Cross section is calculated as:

$$\sigma \times Br(p\bar{p} \to Z \to e^+e^-) = (N_Z - N_{BG})/(A_Z \times \varepsilon \times \varepsilon_{trig} \times \varepsilon_{z0} \times \mathcal{L})$$

	Central-Central	Central-Plug
Acceptance	10.1 ± 0.1%	18.3 ± 0.7%
ID efficiency	92.4 ± 0.4%	79.2 ± 0.4%
Trigger Efficiency	99.9 ± 0.1%	96.8 ± 0.1%
z_0 efficiency	95.2 ± 0.5%	95.2 ± 0.5%
Observed number of events	4568	6954
Estimated background	91.6	194.4
Integrated Luminosity	203.3. ± 12.2	
Z boson cross section	247±15.5	248±15.8

Theory 250 pb

Analysis results

4 events survive the analysis cuts:

Number of events with 2 electrons with $E_T > 25$ GeV	12461
2 jets with $E_T(j1) > 30$ GeV and $E_T(j1) > 15$ GeV	138
removal of events with $76 < M_{ee} < 110$ GeV	46
$E_T(j1) + E_T(j2) > 85$ GeV && $E_T(e1) + E_T(e2) > 85$ GeV	21
$((E_T(j1) + E_T(j2))^2 + (E_T(e1) + E_T(e2))^2) > 200$ GeV	4

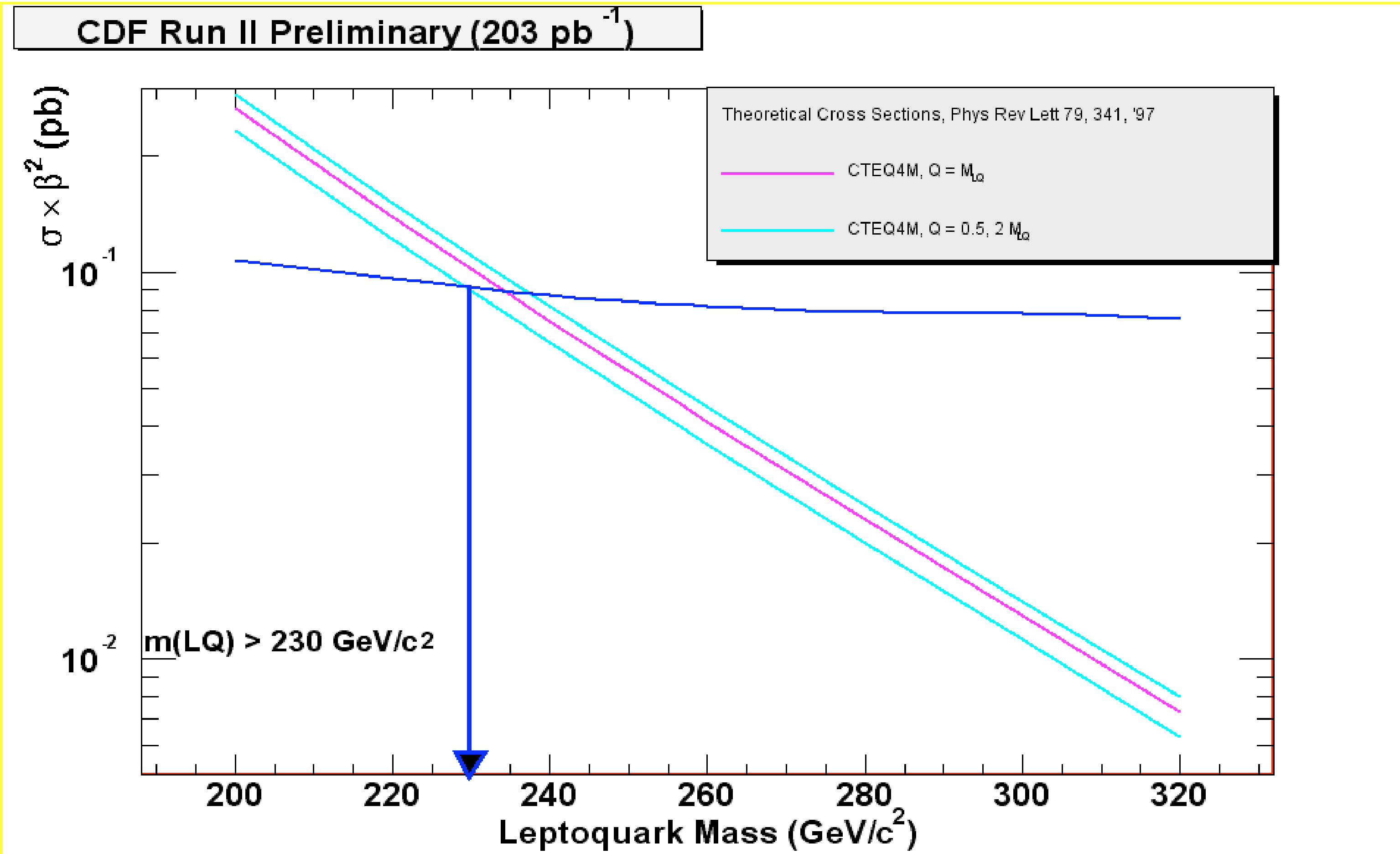
Systematics and combined relative uncertainty

- Luminosity……6%
- Acceptance
  - pdf …… 4.3%
  - statistical error of MC…….. 2.2%
  - jet energy scale …7.6 -1.3 %
- Electron ID efficiency (Z') …0.8%
- Event vertex cut …….5%

LQ mass	Acceptance (%)	Abs Stat	Abs Sys	Tot Relative
200	32.24	± 0.85	± 4.57	0.14
220	35.07	± 0.79	± 4.13	0.12
240	38.11	± 0.80	± 3.8	0.10
260	40.4	± 0.82	± 3.7	0.09
280	41.8	± 0.84	± 3.6	0.087
300	41.9	± 0.84	± 3.5	0.084
320	43.3	± 0.84	± 3.4	0.080

Final relative uncertainty on acceptance 13-9%

Cross section Limit



Conclusions

- A preliminary 95% CL cross section lower limit as a function of M_{LQ}, for leptoquarks decaying with 100% branching ratio into eq (□ = 1.0) has been set.
  - CC and CP electrons have been used;
- Comparing it to the NLO theoretical predictions for leptoquark pairs production at the TeVatron, an upper limit on the Leptoquark mass is obtained at

$$m_{LQ} > 230\ \mathrm{GeV}/c^2$$

Difference with previous analysis

- The result presented in this note does not improve the previous result presented in March 2003.
- Signal efficiencies were overestimated due to a typo in the definition of the CC category
  - Basically the sum of all the contributions was used instead of only CC.
- Since we were looking at data in the CC region only (and observed 0 events) the cross section limit was consequently overestimated.
  - Using CC only acceptances in fact would have given a mass limit of order 205 GeV/c^2.
  - On the other hand we checked that, given the good run list used in March 2003, we would have seen 0 CP events as well.
  - This would have made the limit reach 220 GeV/c^2.